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ABSTRACT

From the view of schema-transfer theory, the use of schemata with their several functions gives an explanation for the facilitative effect of prior knowledge on learning processes. This report gives a theoretical exploration of the concept of schemata, underlying schema theories, and functions of schemata to indicate the importance of schema theories in the context of an ongoing research project on prior knowledge state. A schema is a fundamental element on which all information processing depends, a data structure for representing generic concepts stored in memory. Embedded in the unit in addition to the knowledge itself is information about how the knowledge is to be used. The prior knowledge state has a central role in all schema theories. The starting point for constructing a representation is what the learner already knows. It seems obvious that the student's schemata or knowledge structures will give concrete information about their prior knowledge state. Seven figures illustrate the discussion. (Contains 87 references.) (SLD)

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Schema theories as a base for the structural representation of the knowledge state

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SCHEMA THEORIES AS A BASE FOR THE STRUCTURAL REPRESENTATION OF THE KNOWLEDGE STATE

OTIC Research Report 18

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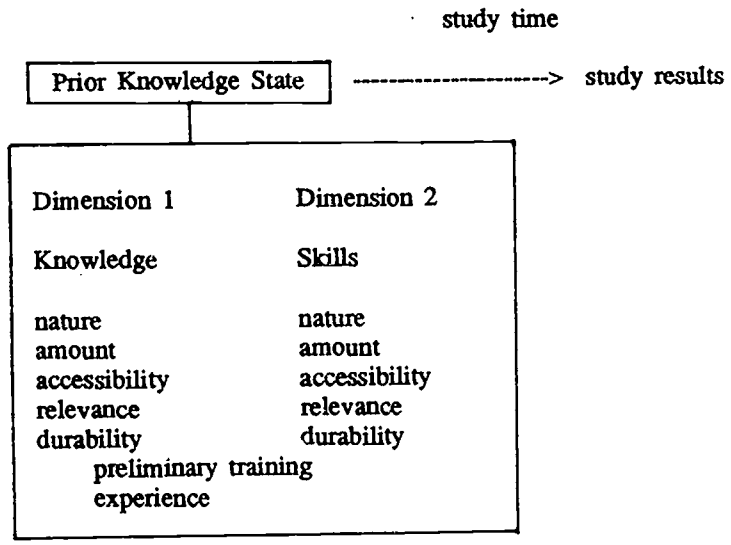
1. Introduction: the knowledge state of the student and schemata

In cognitive psychological research there have been some attempts to understand more about the role of the domainspecific knowledge state, that means the knowledge state comprising information and skills.
With respect to a theory of acquisition, De Corte (1988) states that a number of characteristics of learning processes have become more and more research-based: e.g. the importance of prior knowledge in general, informal knowledge and skills in particular, the need to anchor learning in real life experience, etc.
Mostly this research into the understanding of new information takes the schema concept as a starting-point (Anderson and others, 1977; Rumelhart and Ortony, 1977; Adams and Collins, 1979; Collins and others, 1980). According to Resnick (1981), the notion of a schema as a framework for interpreting the text is central to virtually all of the work on prior knowledge.

The notion of schema is important for our research, especially as a describing concept of existing knowledge, in which the structure of the prior knowledge is emphasized. Schemas or strongly organized prior knowledge is the product towards which learning and education are finally directed (Bransford, Nitsch and Franks, 1977). According to Anderson, Spiro and Anderson (1978) the schemata a person already possesses are a principal determiner of what will be learned ...". From the view of the schema-transfer theory, the use of schemata with their several functions give an explanation for the facilitative effect of the prior knowledge on learning processes.

In earlier research reports (Dochy, 1988; 1989) we have described a conceptual model for research into the student's prior knowledge state (PKS) (figure 1). The cognitive structure seemed to be important for further research to draw conclusions about the two dimensions of the Prior Knowledge State, i.e. the skills-dimension and the knowledge dimension
(Bouwens & Dochy, 1988).



Figuur 1: A conceptual model for the study of the PKS

We assume that the study of schemata or cognitive structures can tell us more about the nature, the accessibility and relevance of the student's knowledge state, i.e. knowledge and skills, in a learning process. According to Glaser (1987), in investigating the acquisition of knowledge, there is a need to examine how cognitive structures are modified and combined - how students use prior knowledge in the course of learning. In this report it's not our intention to give the most recent developments an exhaustively treatment but to give a theoretical exploration of the concept of 'schemata', underlying schema theories and functions of schemata to back up the above mentioned assumption, in order to describe the importance of schema theories in the context of the PKS research project.

In order to understand the following theoretical enunciation we will give a temporarily description of the concept schema.
A schema is a fundamental element upon which all information processing depends. Imagine it as a unit in which knowledge is packaged. Embedded in this unit is in addition to the knowledge itself, information about how this particular knowledge is to be used.

2. Schematical anticipation and apperception: the schema concept in historical perspective

The use of the concept 'schema' started in the beginning of the 20th century when the Würzburger school of cognitive psychology was directed by O. Külpe. At that time the 'schematical anticipation' was a central issue in the psychological theory of O. Selz. De Groot (1946, 1978) also attributed a central place to the notion of total schema in his theory of thinking. Moreover the older psychologists as Woodworth in his 'Experimental Psychology' (1938) and Bartlett in his work 'Remembering' (1932) used the concept of schema.
Much earlier the same explanatory models were used by the name 'apperception' (van Parreren, 1981). This term was introduced by the seventeenth century filosophist Leibniz and played an important role in Kant's famous work 'Kritik der reinen Vernunft' (1781). A comparative analy-sis of the consequences of the process of apperception on the one hand and the activity of schemas on the other hand showed the conformity between both of the theoretical conceptions (van Parreren, 1981). The successor of Kant at the university of Königsberg, Herbart, attributed a pure psychological meaning to the notion of schema. Herbart's apperception theory and the related work of Wundt had a great influence on educational psychology. Remarkably is for example that the mobilising of prior knowledge, as recommended by Peeck (1979), is equal to the first of Herbart's five 'Formalstufen', the 'Fase der Vorbereitung'.
Following the main ideas of Kant and Herbart, the first who integrated the notion of schemas in his theory was Jean Piaget (1896 - 1984).
In his theory the schema is the basic unit of cognitive structure and is inferred from behaviour. The sources of intellectual operations are found in preverbal sensory-motor schemas and con-cept schemas. From this point of view, Piaget studied the evolution of knowledge. The acquisition of knowledge is the result of a process dominated by experience and deduction. In his epistemology Piaget made a distinction between physical and logical-mathematical experience. Physical experience exists of working with objects and abstracting knowledge from the object itself (experimental knowledge). Logical-mathematical experience is working with objects and abstracting knowledge from the actions (logical-mathematical knowledge). Schemas incorporate the results of experience and influence perception through assimilation and accommodation, two invariant functions in Piaget's theory. Assimilation presupposes an interpretation of something in external reality to assume some kind of meaning in the subject's cognitive organization. The subject can incorporate only those components of reality its structure can assimilate without drastic change. On the other hand new information that calls for behaviour that lies beyond the scope of the subject's present level of cognitive structure induces the structure to change or accommodate themselves in order to handle the information. Assimilation is represented in the model by the addition of data to the data structures as new words and new concepts and templates for word combinations are added. The process of accommodation is represented in the model by the reorganizing of the data. So, accommodation refers to the subject's tendency to modify its structures according to the pressures of the environment, while assimilation involves using current structures which can deal with the environment.

3. The schema concept

The notion 'schema' is often defined as an 'abstract knowledge structure' (Anderson and Pinchert, 1978) or 'an abstract description of a thing or event' (Pinchert and Anderson, 1977).
Rumelhart and Ortony (1977) described schemas in a more concrete way as "data structures for representing the generic concepts stored in memory. They exist for generalized concepts underlying concepts, situations, events, actions and sequences of actions". A direct link between the notion of schemas and the prior knowledge state was given by Neisser (1976). In his perception a schema is that portion of the perceptual cycle which is internal to the perceiver, modifiable by experience, and somehow specific to what is being perceived. The schema accepts information as it becomes available at sensory surfaces and is changed by that information; it directs movements and exploratory activities that make more information available, by which it is further modified.

In this report we will use the schema concept as the basic unit of the knowledge structure, a construct which refers to the format of organized knowledge. In the next section, we will try to describe this concept in a more concrete way.

4. Schema theories and knowledge representation

In this chapter, we will give a short overview of the main schema theories and their implications for representing knowledge.

The well-known theories of Minsky (1975) and Rumelhart (1975) are theories about the representation of knowledge and the influence of this representation on knowledge acquisition. These two theories show a lot of similarities.
Schemata or abstract information units, containing a model of a situation, are activated through a procedure, comparable with the matching procedure. Through confrontation with a given situation, the variables in the model are given a value. Variables that do not appear in this concrete situation, grant a value based on the schema of the subject. The schema contains default assignments for each variable. Places filled by default assignments or by incoming information are socalled slots.

In other words, schemata are modifiable information structures that represent the information available in our experiences, the interrelationships between objects, situations, events and sequences of events that occur. It contains thus prototypical information about frequently experienced situations and observations (Rumelhart, 1981). The schema theories assume that in the course of learning, a major function of these structures or schemata is the construction of an interpretation of a new situation. Incoming information can be fitted into slots. When enough slots are filled, the schema becomes active. Then it guides and seeks for information to fill the remaining slots and to create a more complete interpretation. Missing information will be completed by defaults or inferences of the subject on the basis of typical information for a particu-lar situation.

Minsky used the notion 'frame' instead of schema. He defines nodes as the singular propositions providing a basic structure to the schema. Slots and fillers represent the different features of the frame. An example of a frame with different slots and corresponding fillers is given in figure 2.

SUPER FRAME:	creatures			
FRAME:	human			
SLOTS:	age	race	nationality	sex
FILLERS:	29	white	danish	male

Figure 2: Slots and fillers in a frame

A well known basic unit of representation is the proposition. Information can be divided into propositions or expressions which can be true or false (Kintsch, 1977).
Node categories and directed arcs are giving further structure. Within the information, nodes can be defined. Each node is part of a sudden node category. The relation between the nodes are defined by arcs (each part of an arc category).
For example, a beginning student in natural sciences studies train movements. His prior knowledge contains the proposition: a train has round wheels of steel. This proposition exists of three nodes: a train has wheels, wheels are round, trainwheels are made of steel. The node category is in this example each time a physical

state. Graesser and Goodman (1984) differentiate between possible node categories: physical state, physical event, internal state, internal event, goal and style. These node categories are further explained in figure 3.

Node category	Identification Criterion	Examples
Physical State (PS)	Statement refers to an ongoing state in the physical or social world	The dragon was large The ant was unable to swim The heroes were not married
Physical Event (PE)	Statement refers to a state change in the physical or social world	The boy fell The stream carried away the ant The man became an uncle
Internal State (IS)	Statement refers to an ongoing state of knowledge, attitude, sentiment, belief, or emotion in a character	The heroes knew about the dragon The mother loved roses The boy did not believe in God
Internal Event(IE)	Statement refers to a state change in knowledge, attitude, sentiment, belief, or emotion in a character	The heroes became angry The heroes heard the cries The man recognized the ring
Goal (G)	Statement refers to an achieved or un-achieved state that a character wants, needs or desires	The dragon kidnapped the daughters
	An action involves a character executing behavior and achieving a goal; there may be goals that are not achieved and plans that are not applied by executing behavior	The lady told the man to stop The ant stung the birdcatcher The baby wanted to eat The father watched television
Style (S)	Statement or phrase that refers to details about the style in which an action or event occured	X occurred quickly C did something with a knife C moved one foot at a time

Figure 3: Six node categories (adapted from Graesser, 1981)

In the given example there are three nodes and node categories (figure 4).

PRIOR KNOWLEDGE NODES	NODE CATEGORIES
a train has wheels	P.S. (physical state)
wheels are round	P.S.
trainwheels are made of steel	P.S.

Figure 4: Nodes and related node categories.

The arc categories that interrelate nodes can be: reason, initiate, manner, consequence, or property.

Arc Category	Definition	Example
Reason (R)	One Goal node is a reason for another Goal node	The dragon's kidnapping the daughters (G1) is a reason for the dragon's carrying off the daughters (G2) R <G2> -> <G1>
Initiate (I)	A State or Event node initiates a Goal node	The state of being hungry (PS) initiates the goal of ingesting food (G) I <PS> -> <G>
Consequence (C)	A State, Event, or action (Goal+) node has the consequence of another State Event node	The aunt being pulled under water (PE1) has the consequence of the aunt drowning (PE2) C <PE1> -> <PE2>
Manner (M)	An Event or action (Goal+) node occurs (Style or Goal node)	The man walked (G+)in a manner that with some style was quick (S) M <G+> -> <S>
Property (P)	A character, object, or entity has some property that is a State node	The man owned a jacket (PS1) that was red (PS2) D <argument of PS1> -> <PS2>

Figure 5: Arc categories that interrelate nodes (adapted from Graesser, 1981)

The proposition 'the wagon moves and the wheels wear out' contains two nodes, two node categories and one arc (figure 6).

NODES	NODE CATEGORIES	ARC CATEGORY
Wagon moves	P.E 1	
	↓ ---- C	
Wheels wear out	P.E 2	

Figure 6: Example of nodes, node categories and arcs

Kintsch and van Dijk (1978) specify the relations among propositions and nodes by considering the 'macro-structure'. It is clear that the macrostructure view is similar to the postulated units of information called 'schemata' or 'scripts'.
Rumelhart has stressed the fact that schemata exist on different abstraction levels (nodes), which means that schemata can be included in other schemata or can comprise (sub)schemata themselves. A schema of a building could include an officeschema; this schema could include a typewriting schema.
Rumelhart and Ortony (1977) state that in filling up the missing places some variation is pos- sible without a loss of validity of the schema. This flexibility makes it possible to use the face schema for example to look at cartoons, at pictures of Picasso or the one eyed cyclop in the Odyssee.

The 'script' theory of Schank and Abelson (1977) can be differentiated from the former theories by the fact that scripts include a time factor. The well-known restaurant script exists of a cast of characters, including the customer, the waiter, the cook, the cashier and the owner, and a time

series of scenes, for example the entering scene, the ordering scene, the eating scene and the exiting scene (see figure 6). Also, it has been stated that in a script, the individual is an actor or an observer. Scripts involve the individual in some way (Abelson, 1976). According to Abelson, we have scripts for familiar behavioral sequences (going to your office, to the doctor), areas of knowledge (writing articles, computer programming), and so on.
Schank (1980) also used the notion 'memory organization packets'.

Name:	Restaurant		
Props:	Tables	Roles:	Customer
	Menu		Waiter
	Food		Cook
	Bill		Cashier
	Money		Owner
	Tip		
Entry Conditions:	Customer hungry	Results:	Customer has less money
	Customer has money		Owner has more money
			Customer is not hungry
Scene 1:	Entering		
	Customer enters restaurant		
	Customer looks for table		
	Customer decides where to sit		
	Customer goes to table		
	Customer sits down		
Scene 2:	Ordering		
	Customer picks up menu		
	Customer looks at menu		
	Customer decides on food		
	Customer signals waitress		
	Waitress comes to table		
	Customer orders food		
	Waitress goes to cook		
	Waitress gives food order to cook		
	Cook prepares food		
Scene 3:	Eating		
	Cook gives food to waitress		
	Waitress brings food to customer		
	Customer eats food		
Scene 4:	Exiting		
	Waitress writes bill		
	Waitress goes over to customer		
	Waitress gives bill to customer		
	Customer gives tip to waitress		
	Customer goes to cashier		
	Customer gives money to cashier		
	Customer leaves restaurant		

Figure 7: The restaurant script. (adapted from Schank and Abelson, 1977)

Other theories have been developed about 'plans' (Lichtenstein and Brewer, (1980); Schmidt, Sridharan and Goodson, 1978), containing not only a time schedule but also a sequence of skills. Schemata or frames are providing possibilities for knowledge representation in semantical networks. The slots or the nodes are then the central concepts in the networks (Brachman and Schmolze, 1985).

Schema theories and learning

Rumelhart and Norman (1978) state that there are three different kinds of learning in relation to their schema theory: accretion, restructuring and tuning.

Accretion is the coding of new information in terms of existing knowledge.

Restructuring is the process of creating new schemata (schema induction through the spatial or temporal connection of information or patterned generation through copying old schemata with some adjustments).

Tuning or schema-evolution is the slow modification of a schema as a result of handling it in different situations.

In this view, again the existing current knowledge is central to the learning process.

We now turn to a discussion of these three modes of learning and the conditions under which they occur.

Accretion

Learning by accretion is probably the most common sort of learning. It is also the sort of learning that has least effect on the operation of the system.

whenever new information is encountered, there is assumed to be some trace of the comprehension process laid down in memory.

This memory trace is the basis for recollections.

Generally these traces are assumed to be partial copies of the original instantiated schemata. Thus, memory traces are assumed to be very much like schemata themselves. They differ only inasmuch as they are fragmentary and they have representations for particular aspects of the original situation in place of the variables of the original schemata.

Such an accumulation of knowledge is the normal sort of learning. Although the accumulation of a substantial body of knowledge may be necessary for more fundamental kinds of learning, it causes no new schemata to be formed.

Tuning

Tuning involves the actual modification or evolution of existing schemata. There are essentially three ways in which schemata can evolve.

First our knowledge of the variable constraints and default values can be upgraded continuously as we continue to use the schemata. Whenever we find a case in which we determine that a certain schema offers an adequate account of a particular situation, we can modify the variable constraints and default values in the direction of the current experience. As this process continues, it will continue to sharpen the variables and default values to make the schema better represent the population of situations to which it is applied.

The second sort of tuning involves replacing a constant portion of a schema with a variable one - that is, adding a new variable to a schema. This sort of schema modification amounts to concept generalization, i.e. making a schema more generally applicable.

The third sort of tuning is, in a sense, the opposite of the last one, namely, the process of making a variable into a constant or specializing the use of the concept.

Restructuring

If accretion and tuning were the only learning mechanisms, no new schemata could be created. The third learning mode discussed previously involves the creation of new schemata. There are basically two ways in which new schemata can be formed: patterned generation and schema induction.

Patterned generation involves the creation of a new schema by copying an old one with a few modifications. Such learning is, in essence, learning by analogy.

The second way in which new schemata can be formed is through the process of schema induction. The notion here is that if a certain spatio-temporal configuration of schemata is repeated,

there is reason to assume that the particular configuration forms a meaningful concept and a schema can be formed that consists of just that configuration. In order for schema induction to work properly, we must posit some aspect of the system sensitive to the recurrence of configurations of schemata that do not, at the time they occur, match any existing schemata. Such a system is not a natural part of a schema-based system.

5. Information-processing and the schema-transfer theory

One could question: what is the evidence to suggest that identifying people's cognitive structures or schemata can tell us more about the effect of prior knowledge?
Herefore we have to refer to the different explanatory theories, reported in research report 1 (Dochy, 1988).
The schema-transfer theory states that the facilitating effect of the prior knowledge state, both at the preservation and the retrieval phase can be explained through the presence of appropriate schemata. So the presence of an appropriate schema ascertained through the reconstructed semantic network and the finding of positive learning effects could give us more information about the PKS-effect we try to explore.
The analysis of the functions of schemata give a better insight in this possible explanatory theory.
The memory model introduced by Atkinson and Shiffrin (1967) contained a sensory memory, a short term memory (STM) and a long term memory (LTM). In schema theories these components are not any longer different chronological phases during information-processing. Perception, understanding and remembering are qualities of the same process. The central and linking factor in this process is the existing knowledge, stored in the LTM.
The act of comprehension can be understood as the selection of an appropriate configuration of schemata to account for the situation (Rumelhart and Norman, 1978).

5.1 Functions of schemata and basic research findings

The conception that the long-term memory is composed of an organized entirety of schemata implicates the assumption that schemata have different functions (Brewer e.a. 1984; Lodewijks, 1983; Posner, 1978):

1. to operate as a framework that serves to preserve new information and skills;
2. to influence the amount of attention allocated to a particular type of information or skills;
3. to produce memory representations that are combinations of old generic information or skills and new incoming information or skills;
4. to serve as a program to guide retrieval processes selectively and goal-directed through the environment;
5. to serve as a framework to guide searches in the human knowledge base while editing;
6. to fill in the gaps in the received information adequately or not.

Schemata can be thought of as 1) preservation-frameworks, 2) selection-programs and 3) production-mechanisms.
In the remainder of this section we will search through the empirical literature to look for unambiguous evidence to support the six different functions of schemata as outlined above.

5.2 Schemata as preservation-frameworks of new information and skills

Schemata can serve as a scaffolding to preserve schema-related information.
Research results show that information which can be instantiated in a schema is better recalled than information which cannot easily be instantiated in a schema. In fact, Ebbinghaus (1885/

1964) found already that the recall for information from a lyric poem was about ten times better than recall of nonsense material. Examples of studies showing that recall is better for material which can be instantiated in schemas are: standard text versus scrambled text (Chiesi, Spilich and Voss, 1979); picture before written passage versus picture after written material (Bransford and Johnson, 1972); title before written passage versus after written material (Dooling and Lachman, 1971; Bransford and Johnson, 1972; Dooling and Mullet, 1973); recognition of organized pictures versus disorganized pictures (Mandler and Johnson, 1976; Mandler and Ritchey, 1977); in proper sequence videotaped actions versus scrambled actions
(Lichtenstein, 1979).
Consequently this so-called framework hypothesis states that schema-related information will be better retained than schema-unrelated information. Besides, there is no assumption made about the level of the information, preserved by the framework. The preserved information can be fairly low-level perceptual information (surface-information) or much more abstract information. Research results supporting this framework function of schemata were obtained by different researchers (Dooling and Lachman, 1971; Bransford and Johnson, 1972; Dooling and Mullet, 1973; Mandler and Johnson, 1976; Mandler and Parker, 1976; Mandler and Ritchey, 1977; Thorndyke, 1977; Anderson, Spiro and Anderson, 1978).

5.3 Schemata as attention-directors towards information

Empirical studies have stated that increased amounts of attention lead to stronger memory traces. However, a distinction has to be made among schema-related and schema-unrelated information. A number of researchers have postulated that schema-related information receives more attention than schema-unrelated information (Bower, 1976; Kintsch and van Dijk, 1978; Cirilo and Foss, 1980). The basic finding of Bartlett (1932) that schema information is better recalled than schema-unrelated information has been replicated many times by researchers using a wide variety of theories about the nature of schemas (Gomulicki, 1956; Johnson, 1970; Meyer and McConkie, 1973; Rumelhart, 1977; Thorndyke, 1977; Mandler and Johnson, 1977; van Dijk and Kintsch, 1978; Goodman, 1980; Lichtenstein and Brewer, 1980; Brewer and Treyens, 1981).
Contrary to this point of view, others have postulated that schema-related information receives less attention than schema-unrelated information (Bobrow and Norman, 1975; Friedman, 1979). A number of studies using a variety of techniques have attempted to control the attentional processes during the studying of written materials and found that this has little effect on schema-based memory findings (Johnson, 1970; Britton, Meyer, Simpson, Holdredge and Curry, 1979; Reynolds, 1979; Graesser, Gordon and Sawyer, 1979; Graesser, Nakamura, Zimmerman and Riha, 1980). Other studies have examined the number and duration of eye fixations on schema-related and schema-unrelated information in viewing pictures. The general conclusion was that individuals devote more attention to schema-unrelated information in photographs (Loftus and Mackworth, 1978; Friedman, 1979).

Although researchers agree upon the attention-directing function of schemata, there is no complete consensus about this. The same conclusions can be drawn about the preservation framework function of schemata. The actual direction is also unclear. Perhaps, this issue will become more clear in the context of a domain-specific analysis.

5.4 Schemata as production-mechanisms for new representations

This production function of schemata, sometimes in the psychological literature called 'integration', refers to the instantiation process. The instantiated schema will contain information from the old schema or generic information and new information from the input. A lot of scientific studies have given evidence for this phenomenon by proving the occurrence of inferences. (Sulin and Doolin, 1974; Jenkins, Wald and Pittenger (1978); Loftus, Miller and Burns, 1978; Brewer and Treyens, 1978; Bower, Black and Turner, 1979; Nicholas and Trabasso, 1980; Graesser et al., 1980; Graesser,

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Robertson and Anderson, 1981; Graesser and Nakamura, 1982; Walker and Yekovich, 1984; Smith, 1984; Graesser and Clark, 1985).
Inferences in recall or recognition tasks give an indication for the process of integration. Inferences can be defined as information, propositions or concepts in recall that are derived from the generic schema and are not in the input information.
Other studies have shown that the integration effect becomes stronger over time (retention interval longer). As the specific episodic information is lost over time, the underlying generic information plays a larger role (Sulin and Dooling, 1974; Mandler and Parker, 1976; Spiro, 1977; Mandler and Ritchey, 1977, van Dijk and Kintsch, 1978; Graesser, Woll, Kowalski and Smith, 1980; Brewer and Dupree, 1983).

5.5 Schemata as a retrieval-mechanism in the knowledge base

Studies have indicated that schemata can function as retrieval mechanisms that are functioning as guides for searching schema-related information in the knowledge base. Evidence can be found in the reports of Pinchert and Anderson (1977), Anderson and Pinchert (1978). They found that the perspective manipulation, for example the view of a house from the point of view of home burglar or buyer, works as a schema-based retrieval plan. Lichtenstein and Brewer (1980), Brewer and Treyens (1981) and Brewer and Dupree (1983) found that immediate recall for actions was more than twice as good and concepts were much more likely to be written down in recall, if they were part of a schema.
Further, a series of investigations show that subjects with a more developed schema for a body of knowledge attain a higher recall for information related to that knowledge (Recall of chess positions by experts and novice players, De Groot, 1978; recall of a baseball game by subjects with high and low knowledge of baseball, Chiesi et al., 1979; recall of narratives about Western and Australian Aboriginal medicine by Western and Australian Aboriginal individuals, Steffensen and Colker, 1982).

5.6 Schemata as a guide-system for search through the environment

Also some evidence has been found for the fact that operational schemata guide the search through the environment. Perspective manipulation for example results in paying more attention to the information related to the corresponding schema (Pinchert and Anderson, 1977; Brewer and Treyens, 1981).

5.7 Schemata as a gapfilling mechanism to edit memory output

This function of schemata can be looked at as two different aspects. First, it says that schemata function as determiners for the information, chosen by the subject (i.e. the schema-relevant information). Second, it says that during this process the schemata can fill in the gaps by means of default assignments. Mandler and Johnson (1977), Mandler (1978), Black and Wilensky (1979), Stein and Glenn (1979), van Dijk (1980), Graesser, Woll, Kowalski and Smith (1980), and Brewer and Treyens (1981) found reasonable evidence for these facts. Schemata operate to edit the information that is recalled. Recent experiments suggest that the editing process is sometimes editing out schema-unrelated information. But, there is more evidence for the as-sumption that the schema-based editing procedure works also by eliminating very high schema-related information.

6. Basic research findings and prior knowledge theories

The basic empirical findings in the study of human learning and memory in relation to schema theories show a lot of evidence in favour of some of the PKS (Prior Knowledge State) theories.

All of these results support in one or another way the retrieval-aid theory, the selective atten-tion theory and especially the accessibility and availability hypotheses.
De Corte (1988) confirms this through the statement that it is a robust finding "that skilled problem solving in a given domain depends to a large extent on the availability of a well-organized and flexibly accessible knowledge base".

7. Conclusion

The term schema is used here to conform with the current usage but also to evoke some similarities with Bartlett's and Piaget's conception of this notion. Schemata are built up in the course of interaction with the environment. They are available at increasing levels of abstraction. Schemata may represent organized experience ranging from discrete features to general categories. The notion of schema is used here as a category of cognitive structures that organize past experience and that include Piaget's invention of the schema as restructuring our experience and being structured by it. The schema that is developed as a result of prior experiences with a particular kind of event is not a carbon copy of that event. It is a representation of environmental regularities (Franks and Bransford, 1971). Schemata operate interactively, i.e., input from the environment is coded selectively in keeping with the schemata currently operating while that input also selects relevant schemata (McClelland and Rumelhart, 1980). Whenever some event produces new and unknown data for the schematic analysis, the activation process proceeds automatically and interactively to the most abstract relevant schema. One assumes that this process of activation of schema is without awareness on the part of perceiver or learner.
One of the assumptions underlying powerful learning environments is that learning is basically a constructive process. Students for example are not passive recipients of information, but they actively construct their knowledge and skills through interaction with the environment, and through reorganization of their own cognitive structures.
The prior knowledge state has a central role in all of the schema theories. The starting point for the construction of a representation is what the learner already knows. Learning is connecting new information to an existing representation. What a learner knows provides the framework for new knowledge. Learning is, according to Norman (1976), a matter of acquiring new structures by constructing new nodes and interrelating them with each other and with existing nodes.

At this moment, there is a renewed interest for schema theories caused by research into text processing and artificial intelligence. First, the research into text processing has shown that processing and recall of information is strongly related to the activation and use of schemata. Second, research into artificial intelligence is developing representation for knowledge of complex situations, closely related to schemata.

An advantage of the schema theory is that it gives the possibility to interpret very complex phenomena and complex behaviour like information-processing.
As noted before, central in this theory is the role of the existing knowledge and skills or prior knowledge state.

Because of this central role, it seems obvious that student's schemata or knowledge structures will give us concrete information about their prior knowledge state. Therefore in one of the following research reports we will give an overview of different methods to construct knowledge structures and we will argue an applicable method and a related instrument.

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